Representation of the Eastern Pacific Intraseasonal Variability and its Impacts on Hurricanes in Climate Models

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Acknowledgment: Duane Waliser (JPL/Caltech), Ming Zhao (GFDL/NOAA), Daehyun Kim (Columbia U.), US CLIVAR MJO Working Group, Modeling Centers

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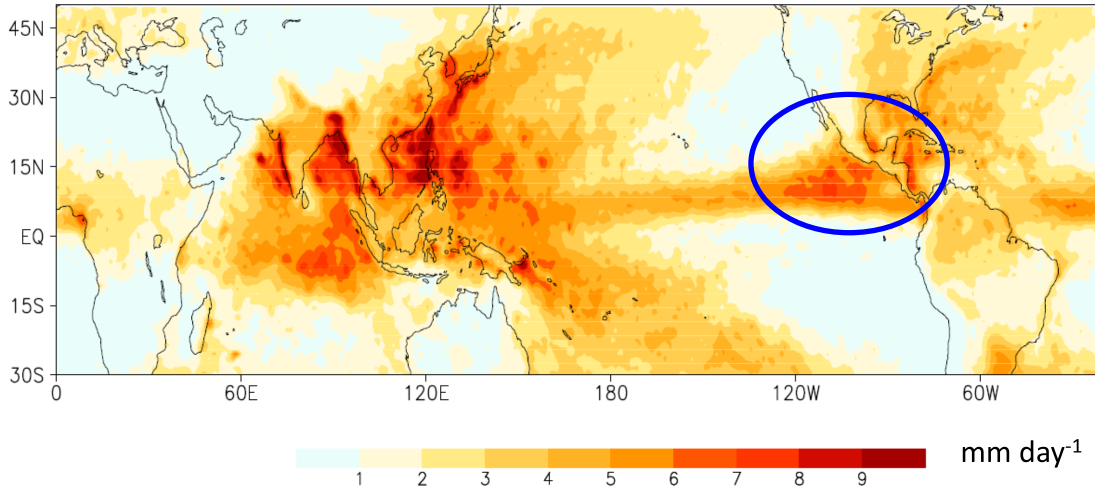
1. Introduction

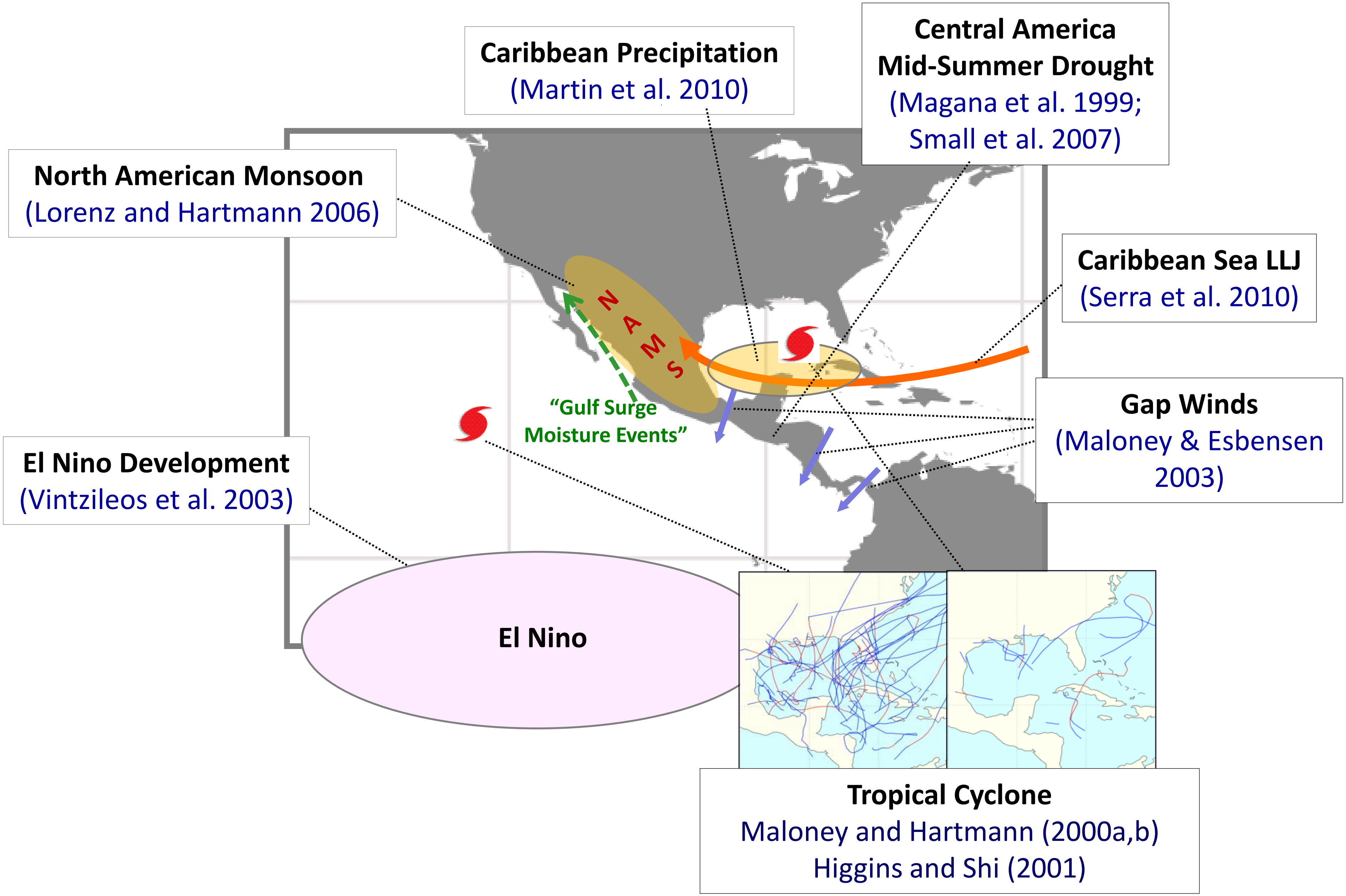
Standard Deviation of Bandpass Filtered Rainfall

Northern Summer (May-Oct)



10-90 day filtered

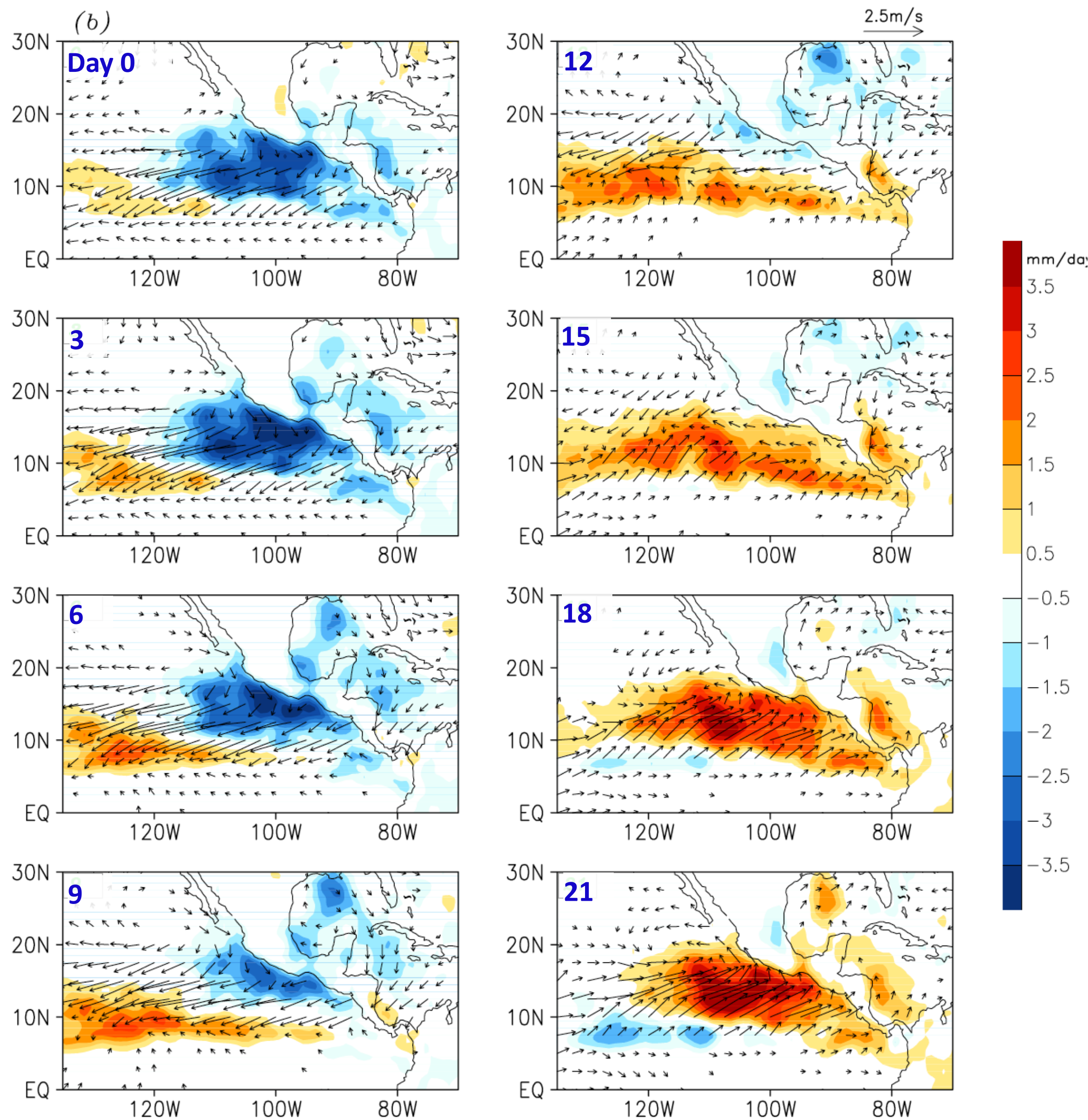
Regional Impacts of ISV over the Eastern Pacific



Evolution of 40-day ISV Mode

Shading: Rainfall
Vectors: QuikSCAT sfc wind

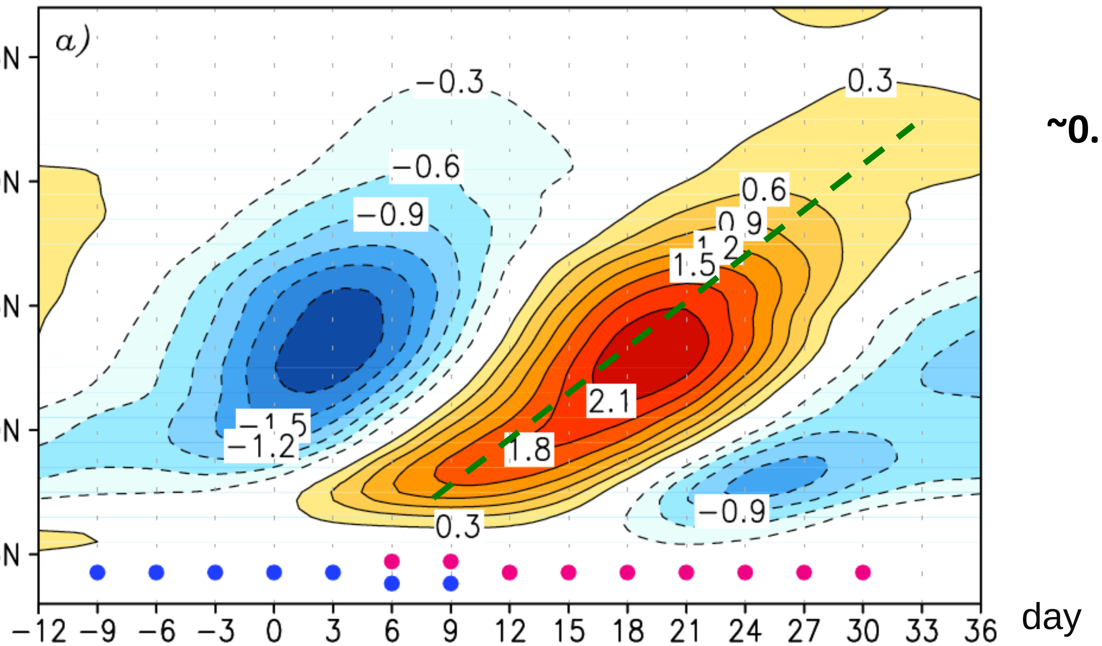
- **Local expression of MJO (cf. Maloney et al; 2007);**
- **Signals from west;**
- **Enhanced convection corresponding to westerly wind anomalies;**



Jiang and Waliser (2008)

40-day ISV mode

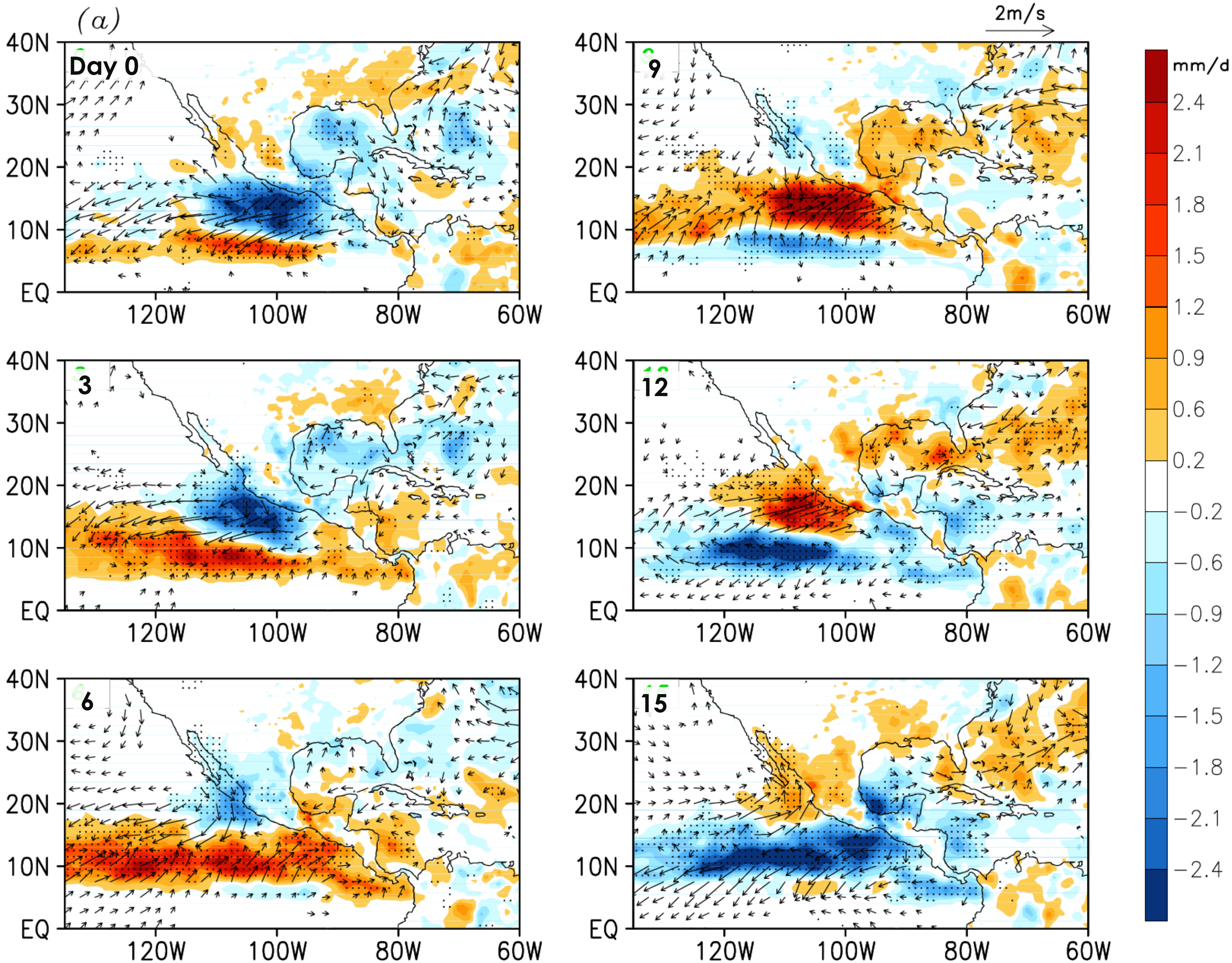
Hovmoller Diagram of Rainfall (130-90°W)



~0.65 deg/day

Jiang and Waliser (2008)

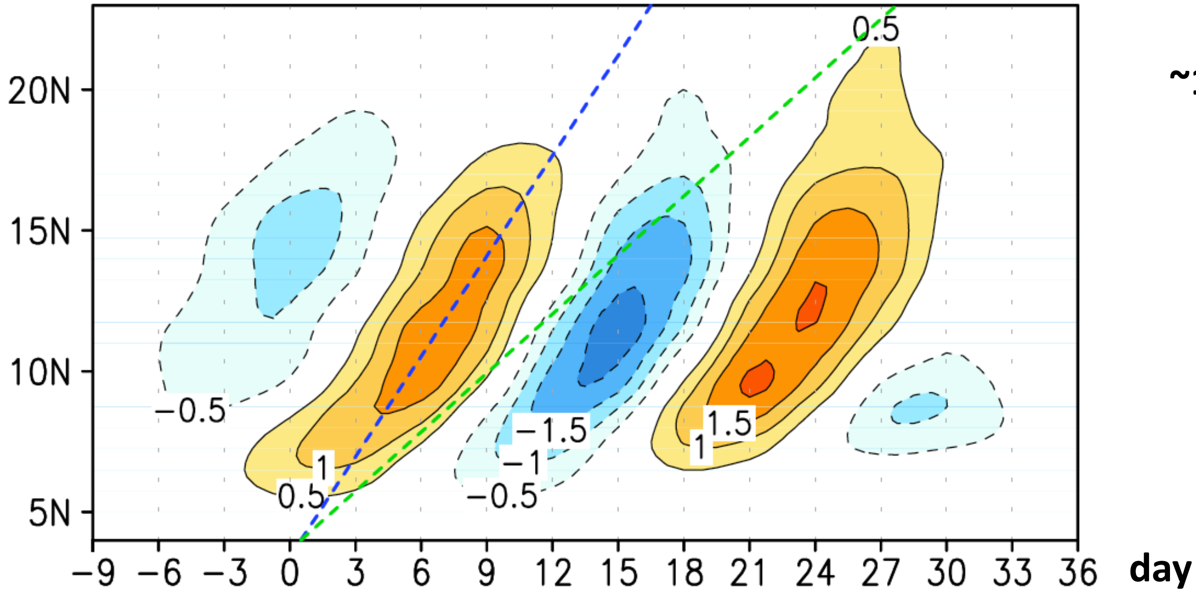
Evolution of the Quasi-Biweekly Mode (QBM)



Jiang & Waliser (2009)

QBM

Hovmoller Diagram of Rainfall (130-100^{o}W)



~1.2 deg/day

Jiang & Waliser (2009)

2. Representation of the two ISV modes in GCMs

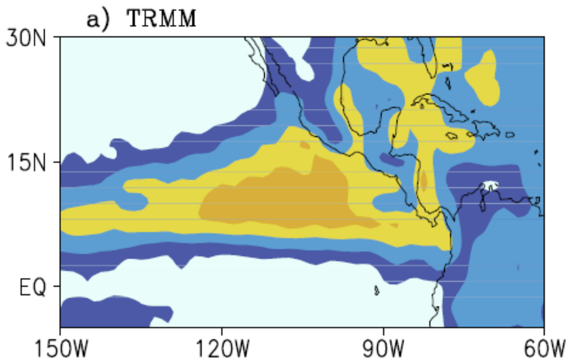
Participating models

Model (group)	Horizontal Resolution -AGCM	Vertical Resolution (top level)-AGCM	Cumulus parameterization	Integration	Reference
CAM3.5 (NCAR)	1.9° lat x 2.5° lon	26 (2.2hPa)	**Mass flux** (Zhang & McFarlane 1995)	20 years 01JAN1986-31DEC2005	Neale et al. (2007)
CAM3z (SIO)	T42(2.8°)	26 (2.2hPa)	**Mass flux** (Zhang & McFarlane 1995)	15 years 29JAN1980-23JUL1995	Zhang et al. (2005)
CFS (NCEP)	T62(1.8°)	64 (0.2hPa)	**Mass flux** (Hong & Pan 1998)	20 years	Wang et al. (2005)
CM2.1 (GFDL)	2° lat x 2.5° lon	24 (4.5hPa)	**Mass flux** (RAS; Moorthi & Suarez 1992)	20 years	Delworth et al. (2006)
ECHAM4/OPYC* (PCMDI)	T42(2.8°)	19 (10hPa)	**Mass flux** (Tiedtke 1989; Nordeng 1994)	20 years	Roeckner et al. (1996), Sperber et al. (2005)
GEOS5 (NASA)	1° lat x 1.25° lon	72 (0.01hPa)	**Mass flux** (RAS; Moorthi & Suarez 1992)	12 years 01DEC1993-30NOV2005	To be documented
SNU-AGCM (SNU)	T42(2.8°)	20 (10hPa)	**Mass flux** (Numaguti et al. 1995)	20 years 01JAN1986-31DEC2005	Lee et al. (2003)
SPCAM (CSU)	T42(2.8°)	26 (3.5hPa)	**Superparameterization** (Khairoutdinov & Randall 2003)	19 years 01OCT1985-25SEP2005	Khairoutdinov et al. (2005)
HIRAM HIRAM_lores (GFDL)	**0.5° lat x 0.6° lon** 2.0° lat x 2.5° lon	32 (4.5hPa)	**Mass flux** (Bretherton et al. 2004)	19 years 01JAN1990-31DEC2008	Zhao et al. (2009)

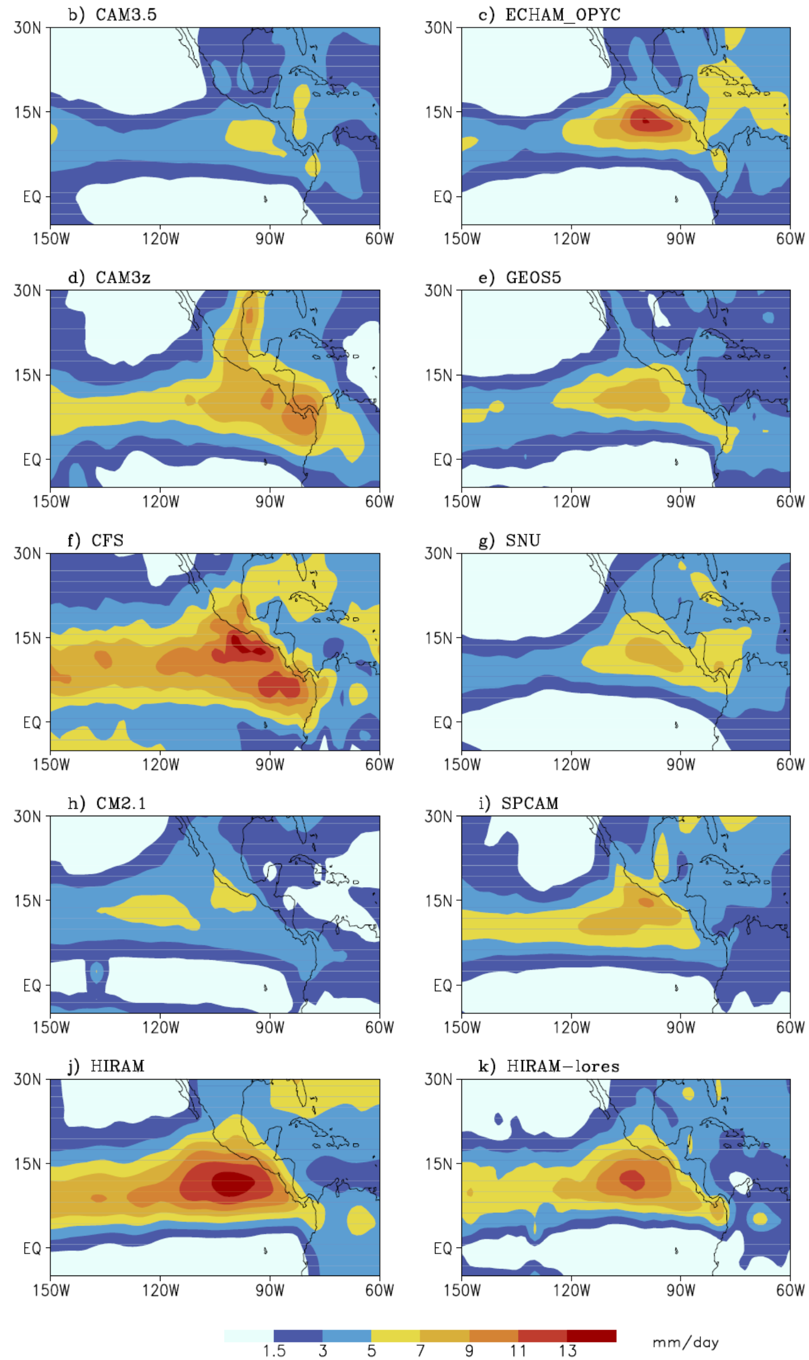
Courtesy of MJO Working Group

Kim et al. 2009

STDs of summer (JJAS) rainfall

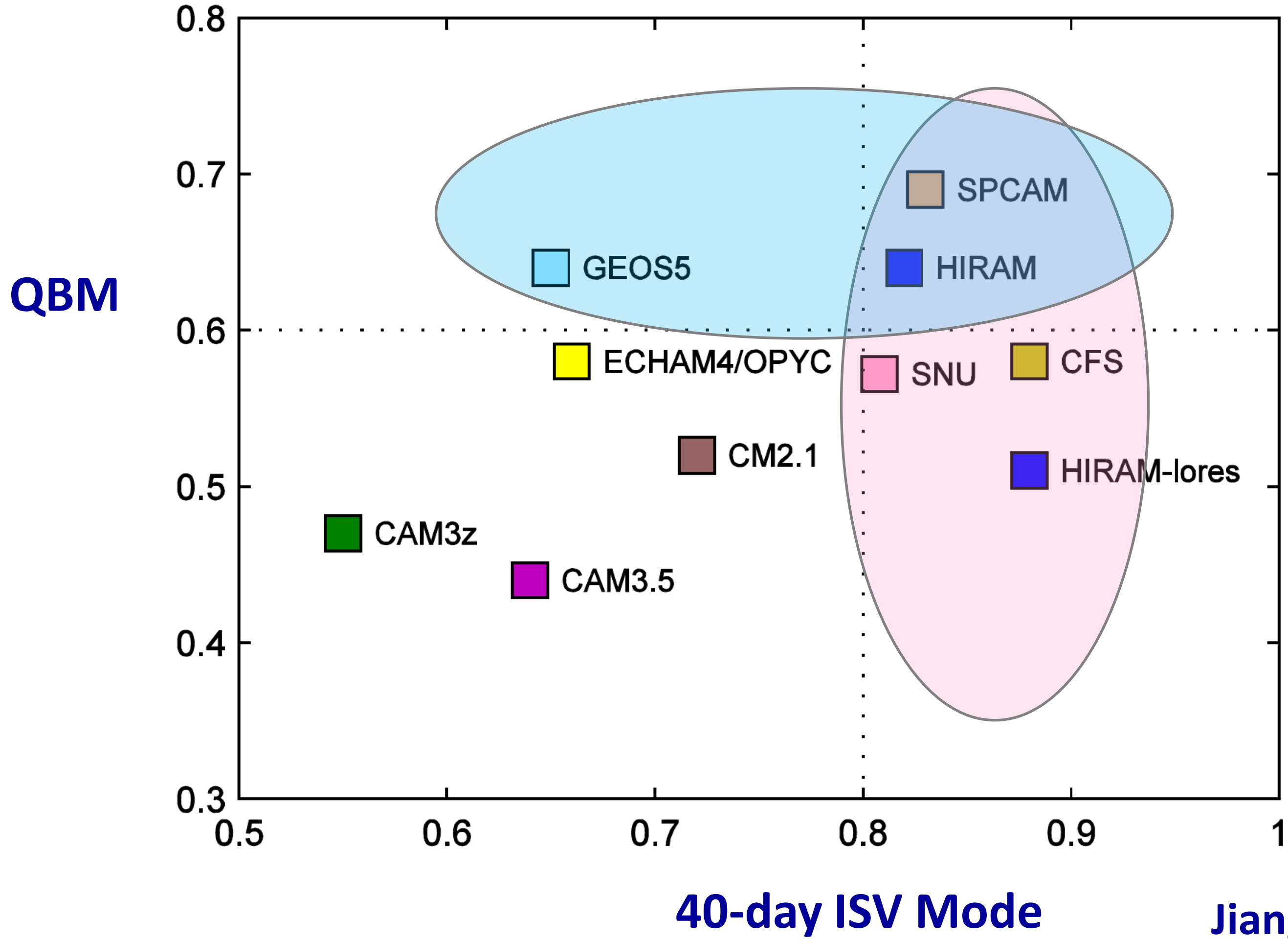


10-90 day filtered



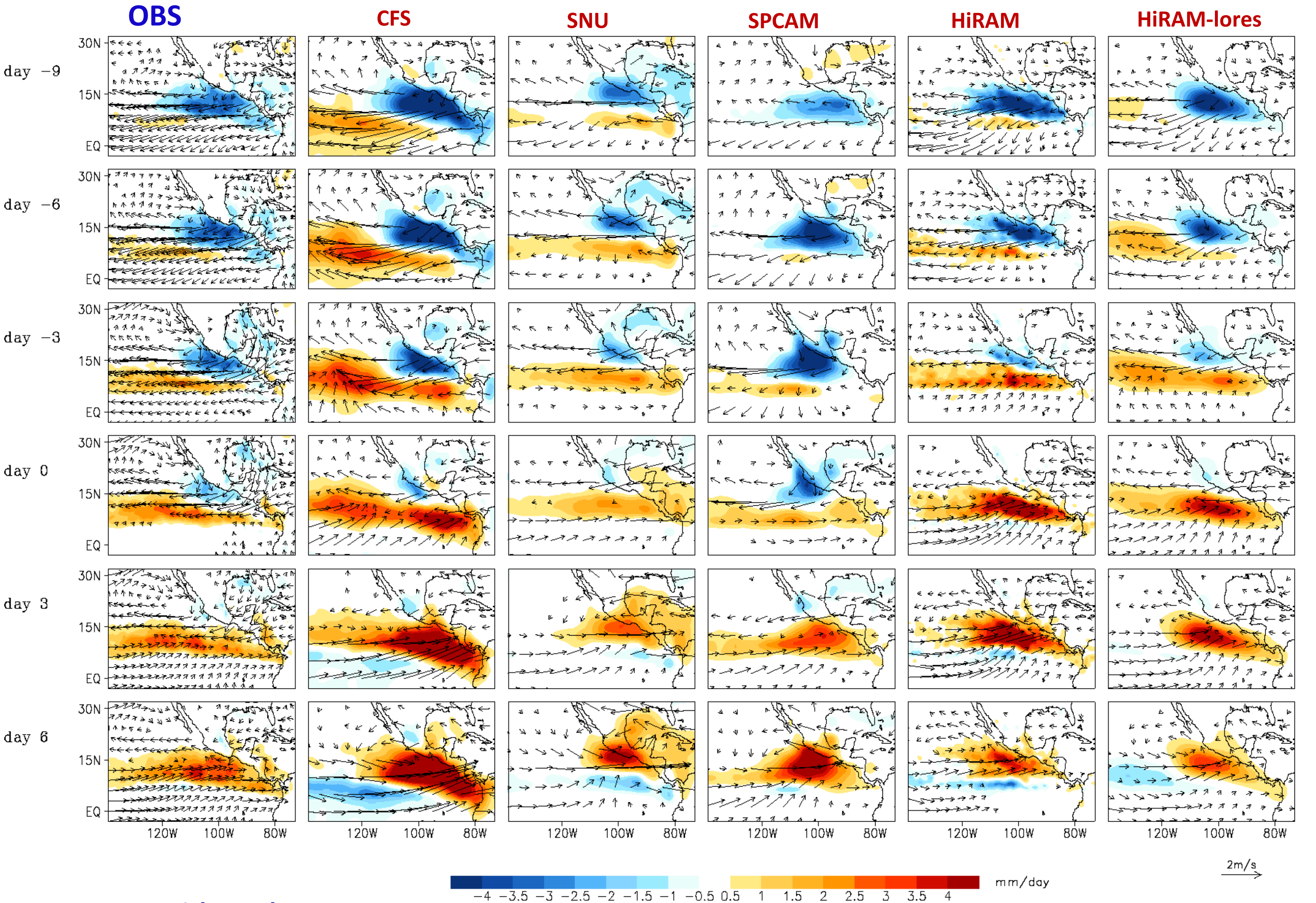
Jiang et al (2011)

Pattern correlations of the two ISV modes between observations and GCM simulations



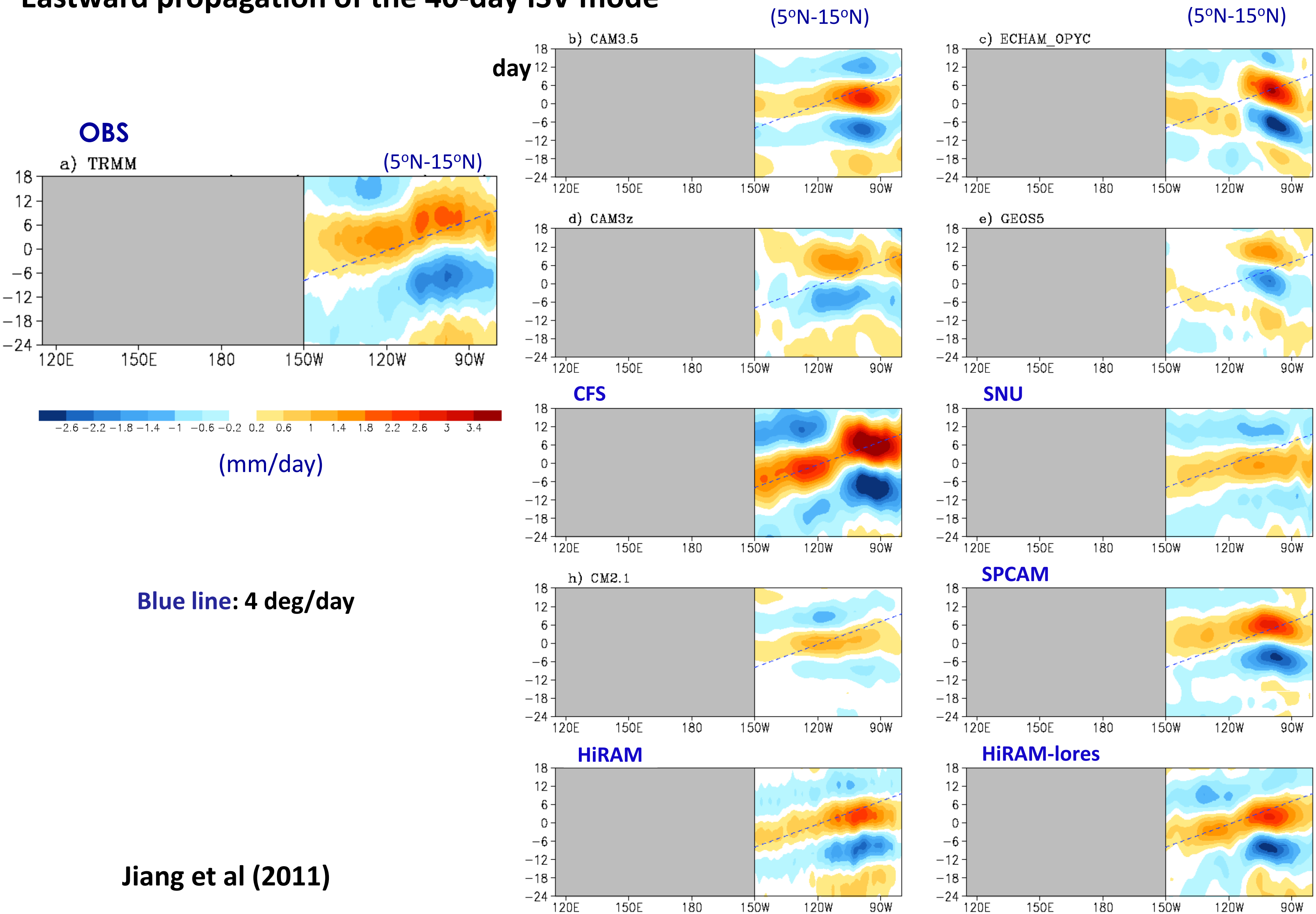
Jiang et al (2011)

Evolution of Rainfall & 850mb wind associated with 40-day ISV mode



Jiang et al (2011)

Eastward propagation of the 40-day ISV mode



Blue line: 4 deg/day

Jiang et al (2011)

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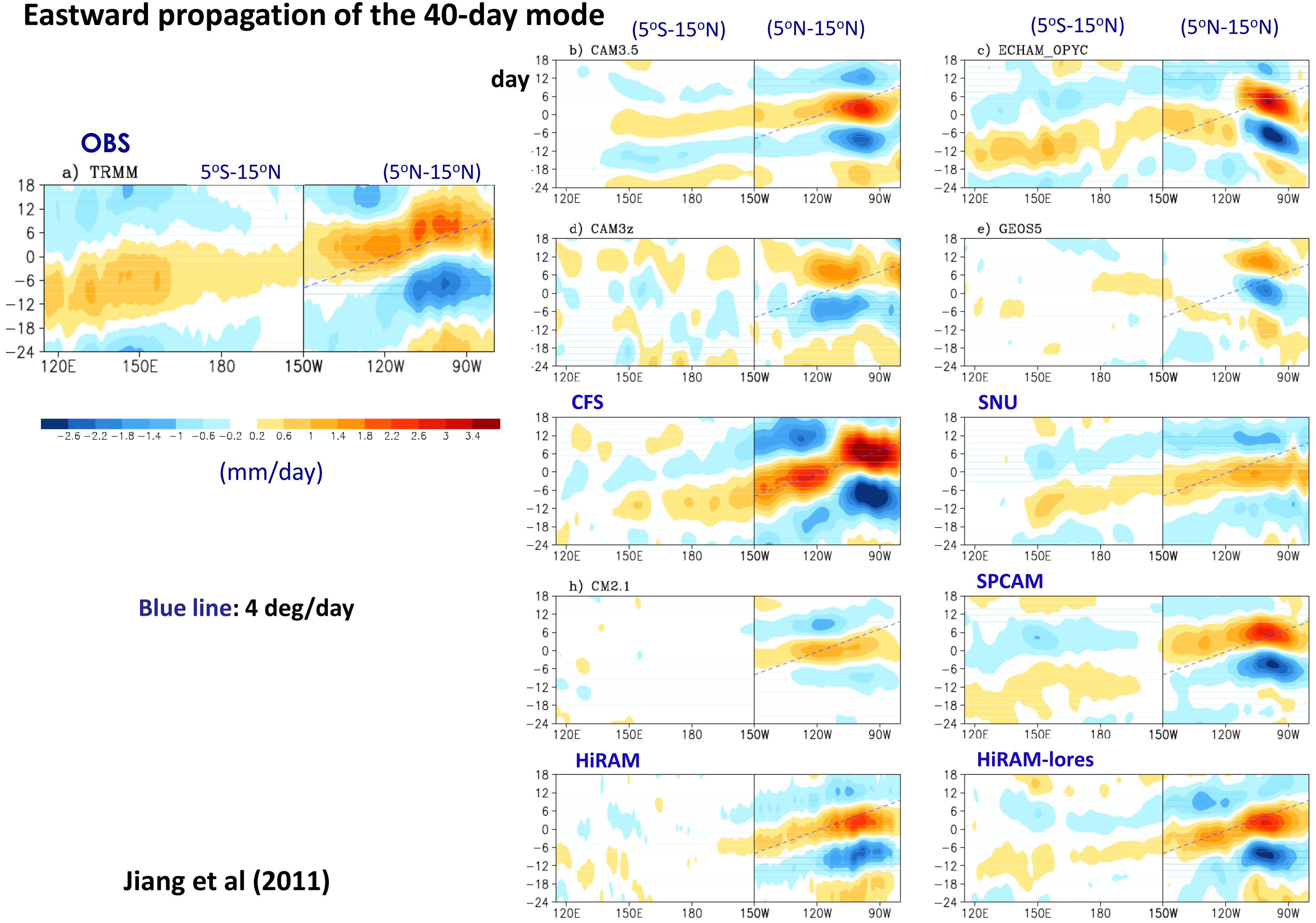
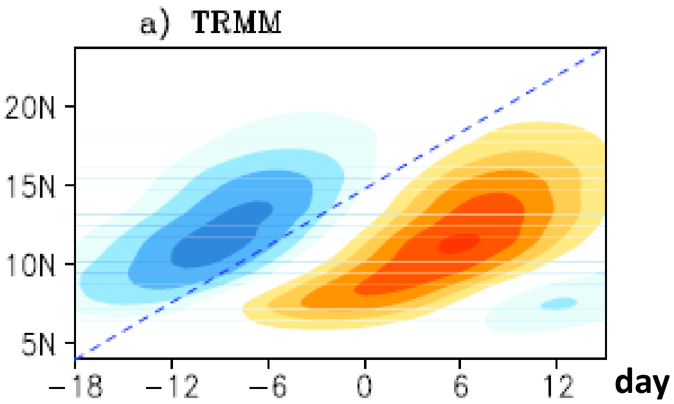


Blue line: 4 deg/day

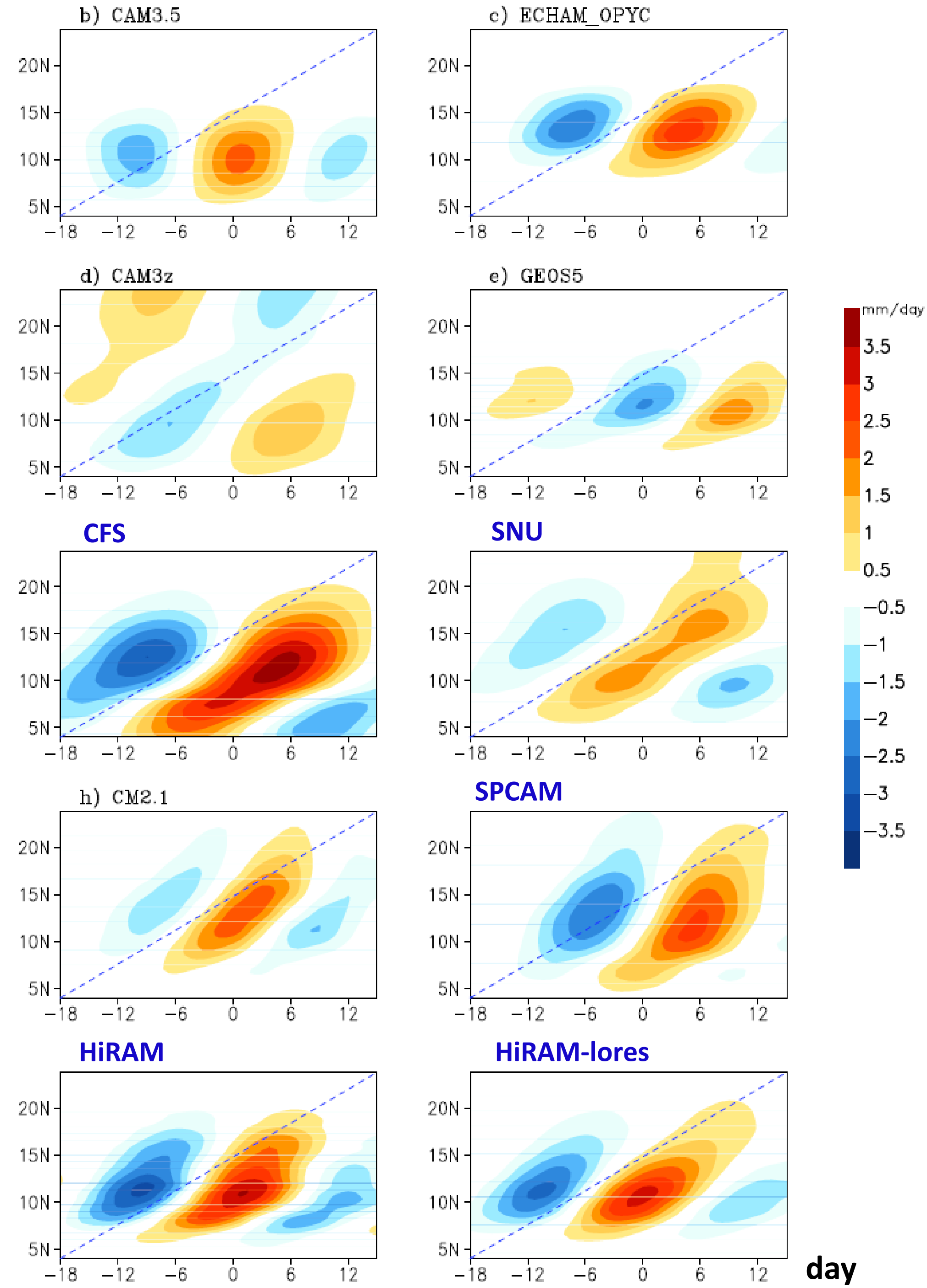
Jiang et al (2011)

Northward propagation of the 40-day mode

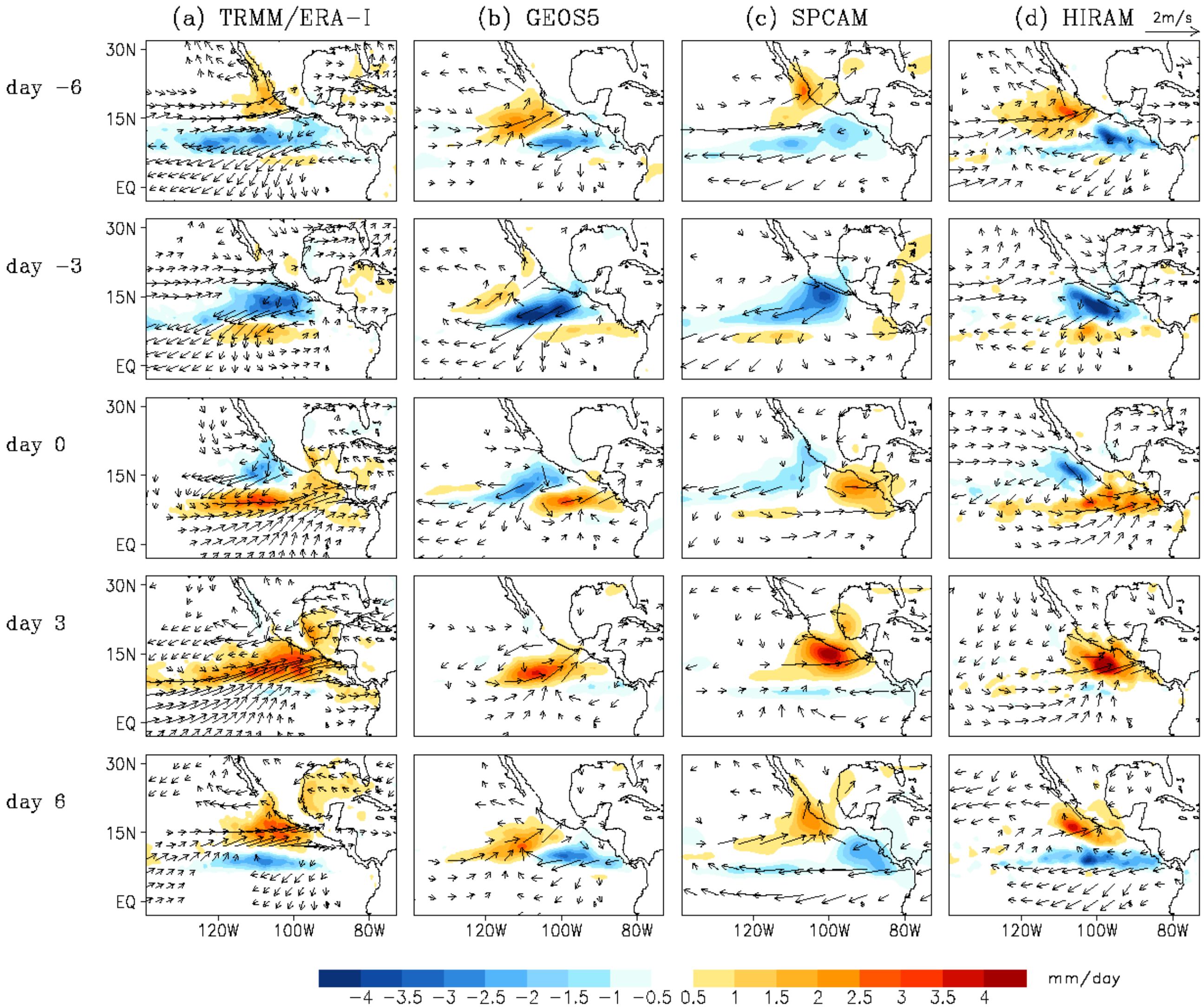


(130°W-90°W)

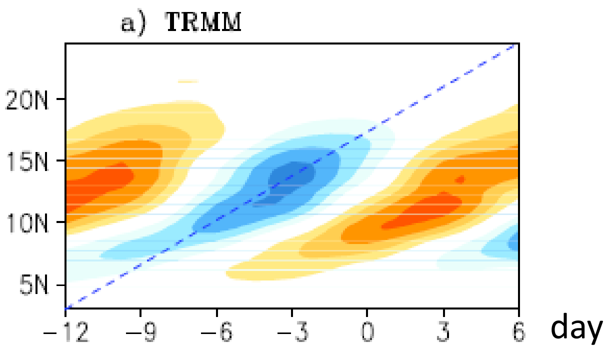
Blue line: 0.6 deg/day



Evolution of Rainfall & 850mb wind associated with the QBM

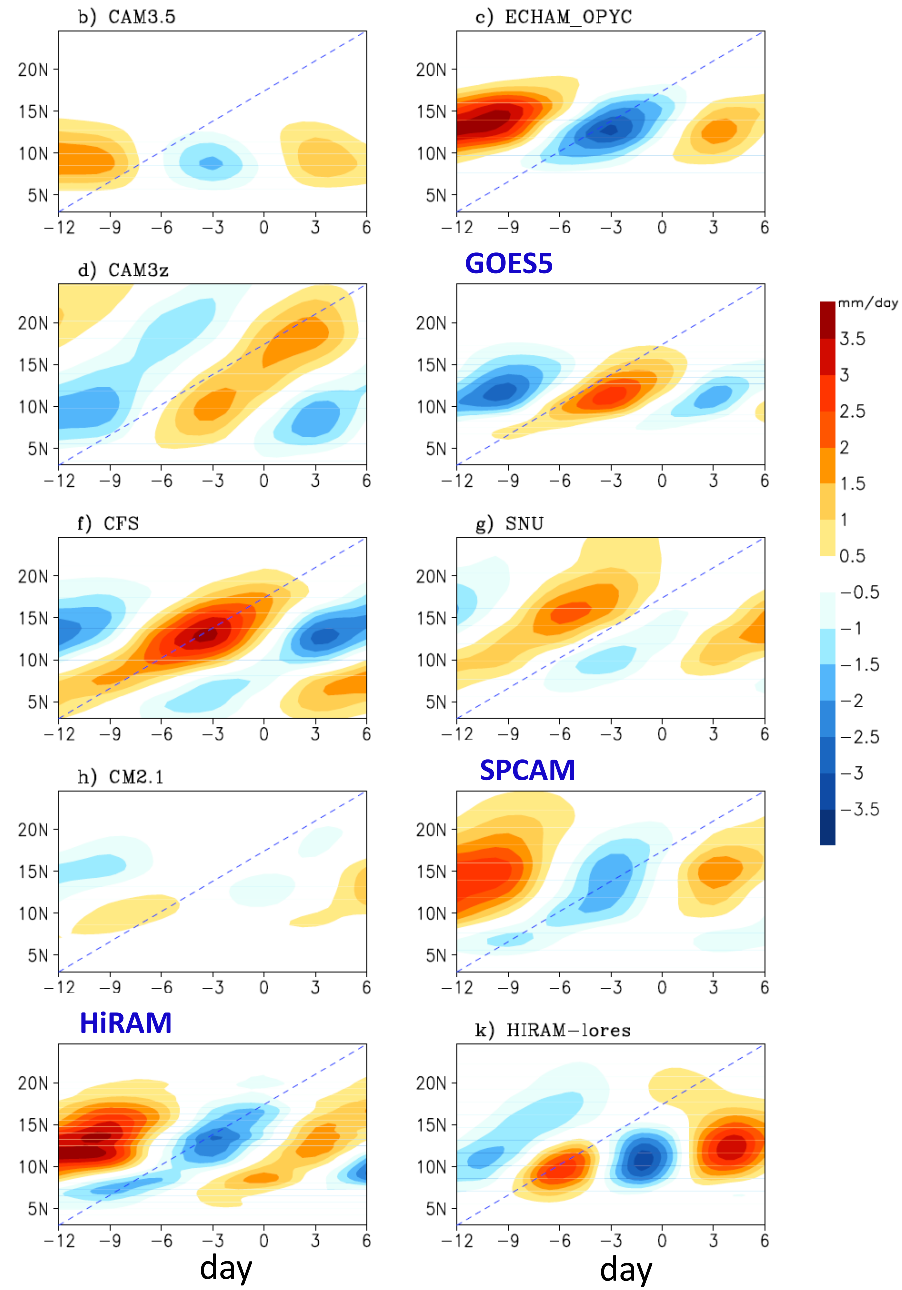


Northward propagation of the QBM



(130ºW-90ºW)

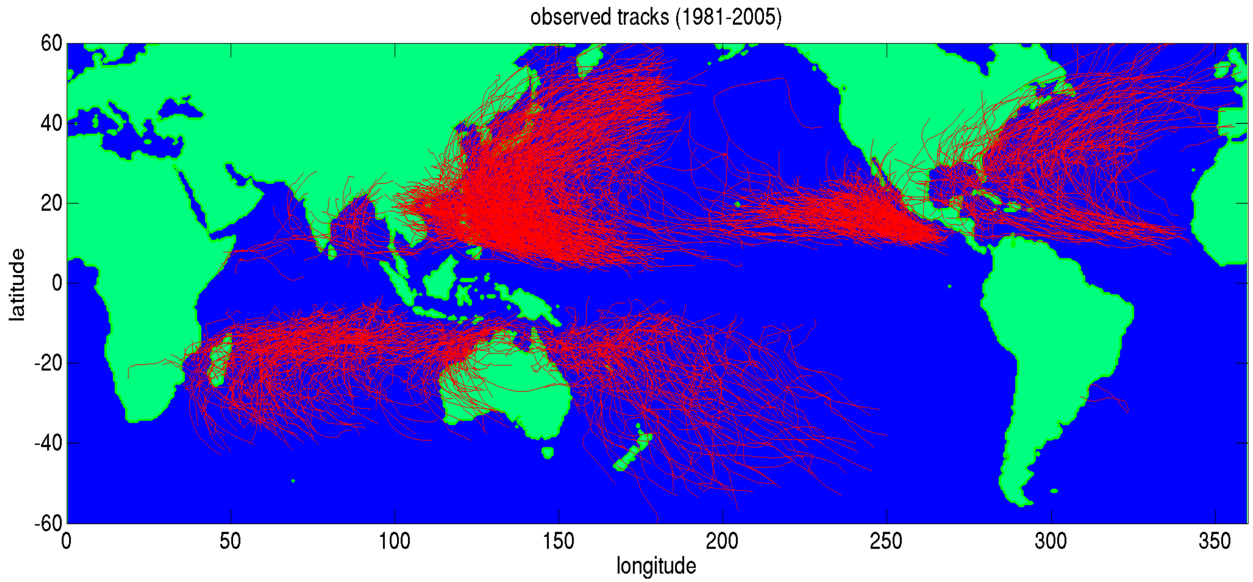
Blue line: 1.2 deg/day



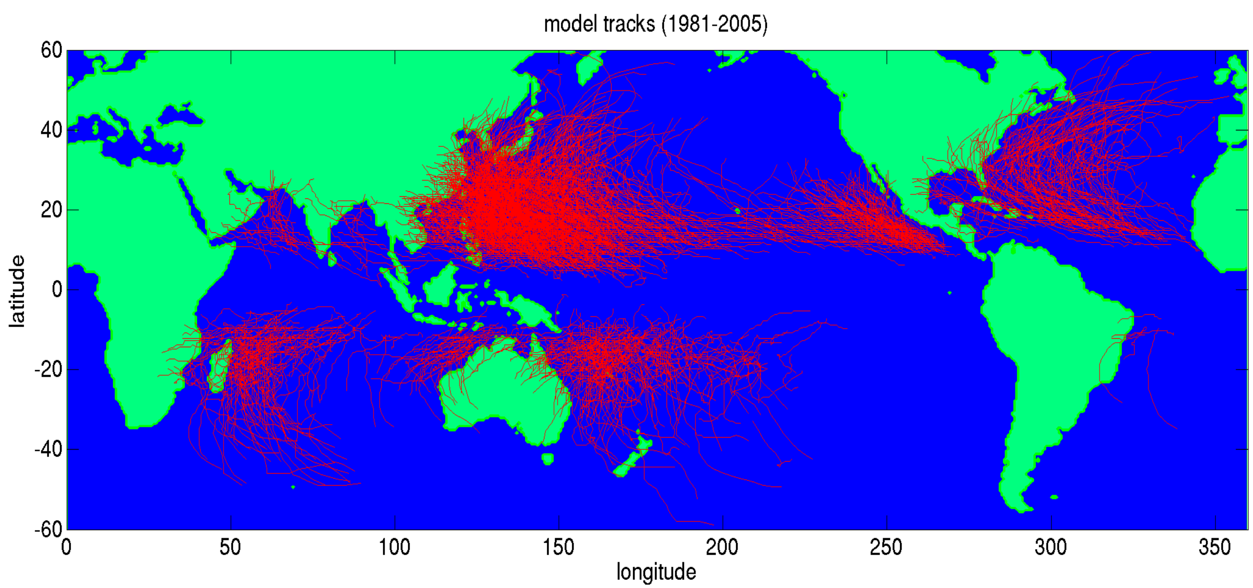
3. Modulation of hurricanes by the ISV over the EPAC in GFDL HiRAM

HiRAM2.1 captures geographical distribution of hurricane tracks (1981-2005)

Observation



HiRAM2.1

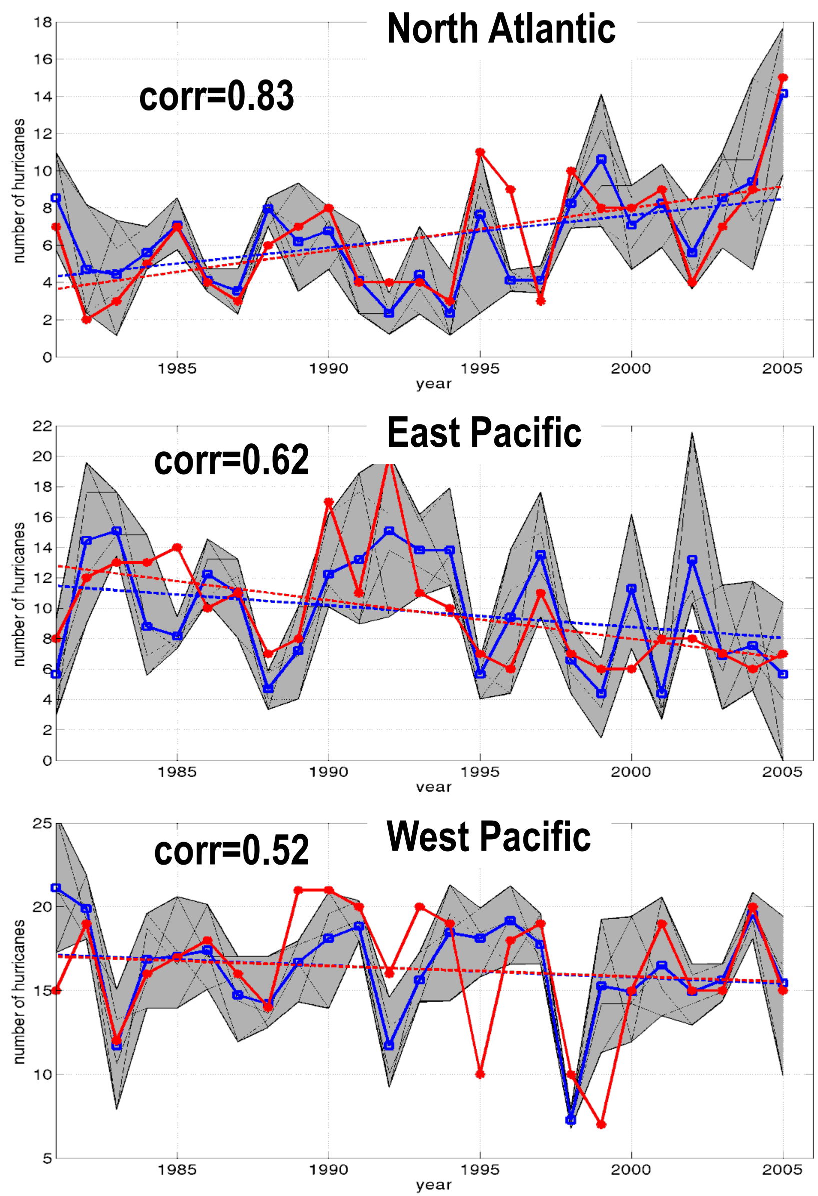


Zhao et al (2009)

HiRAM2.1 captures both the inter-annual variability and decadal trend over the N. Atlantic, the E. and W. Pacific

Red: Observations
Blue: HiRAM ensemble mean
Shading: Model spread

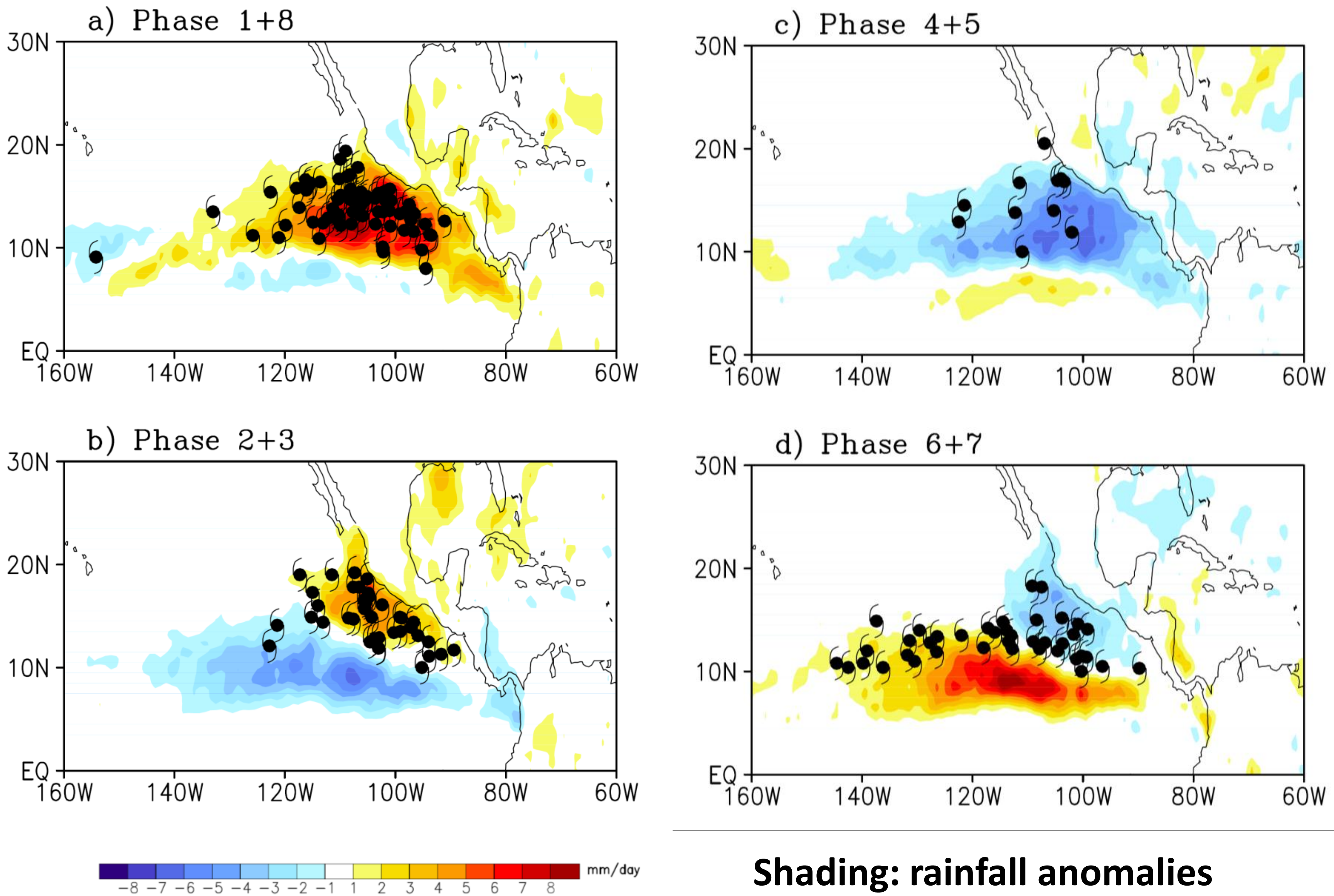
Model time-series are normalized to observed time-mean



Zhao et al. (2009)

ISV and TC genesis (1998-2008): OBS

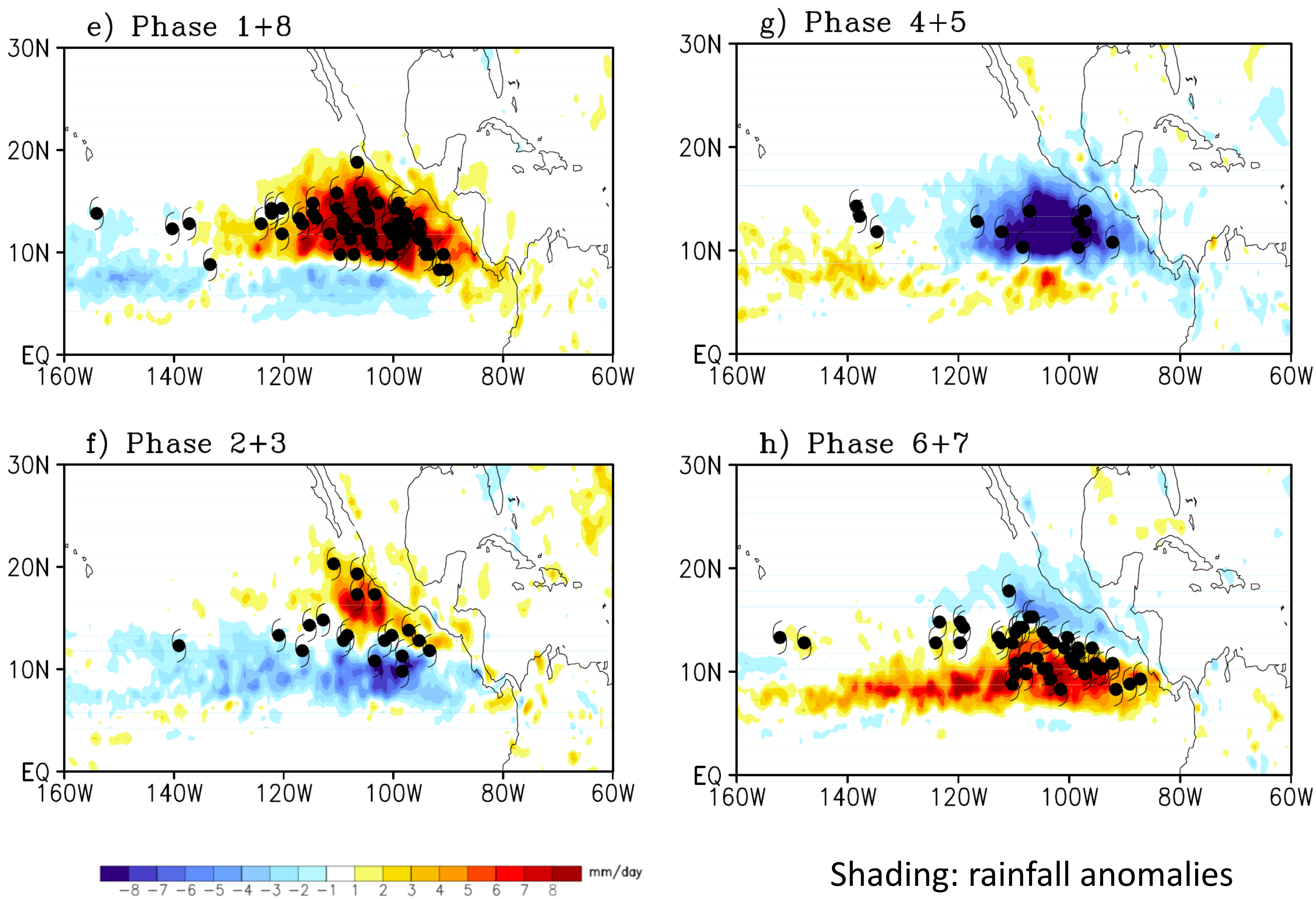
Jiang et al. (2011b)
J. Climate



Shading: rainfall anomalies

ISV and TC genesis (1998-2008): HiRAM

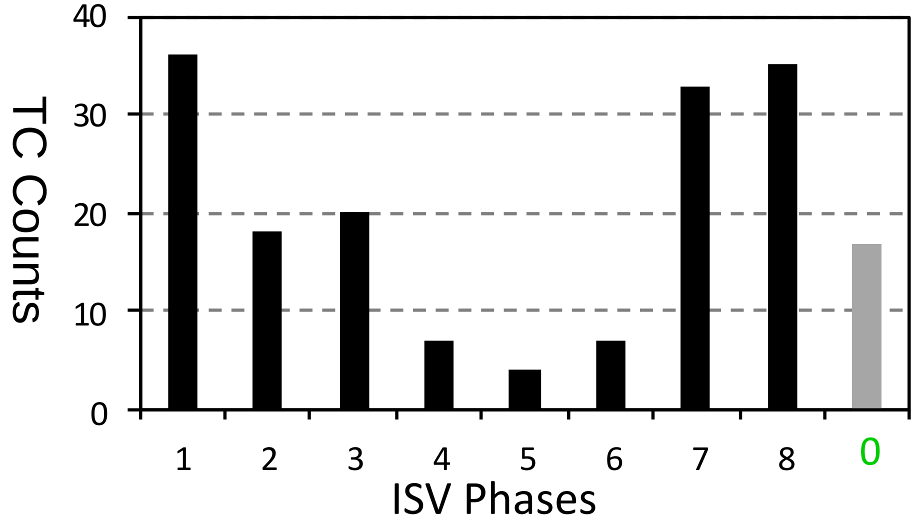
Jiang et al. (2011b)



Shading: rainfall anomalies

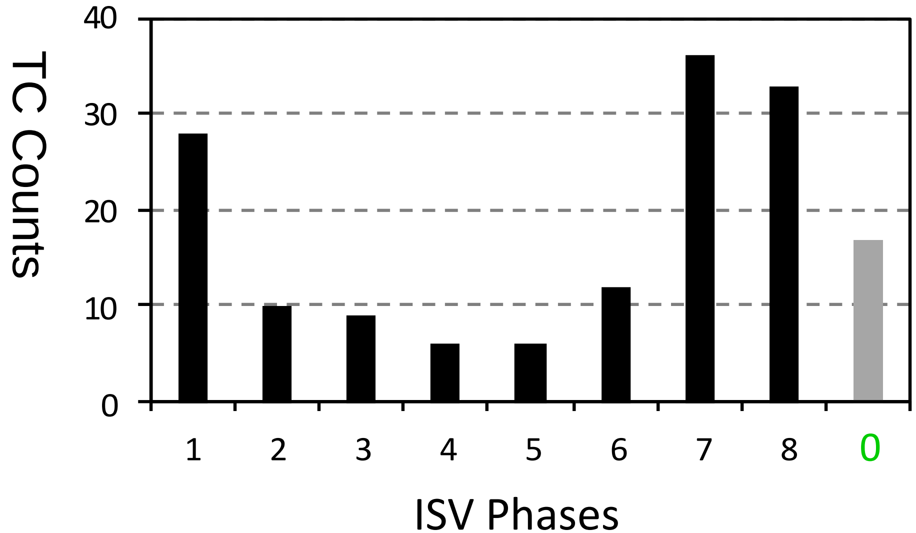
TC Genesis counts over the EPAC and ISV Phases

OBS

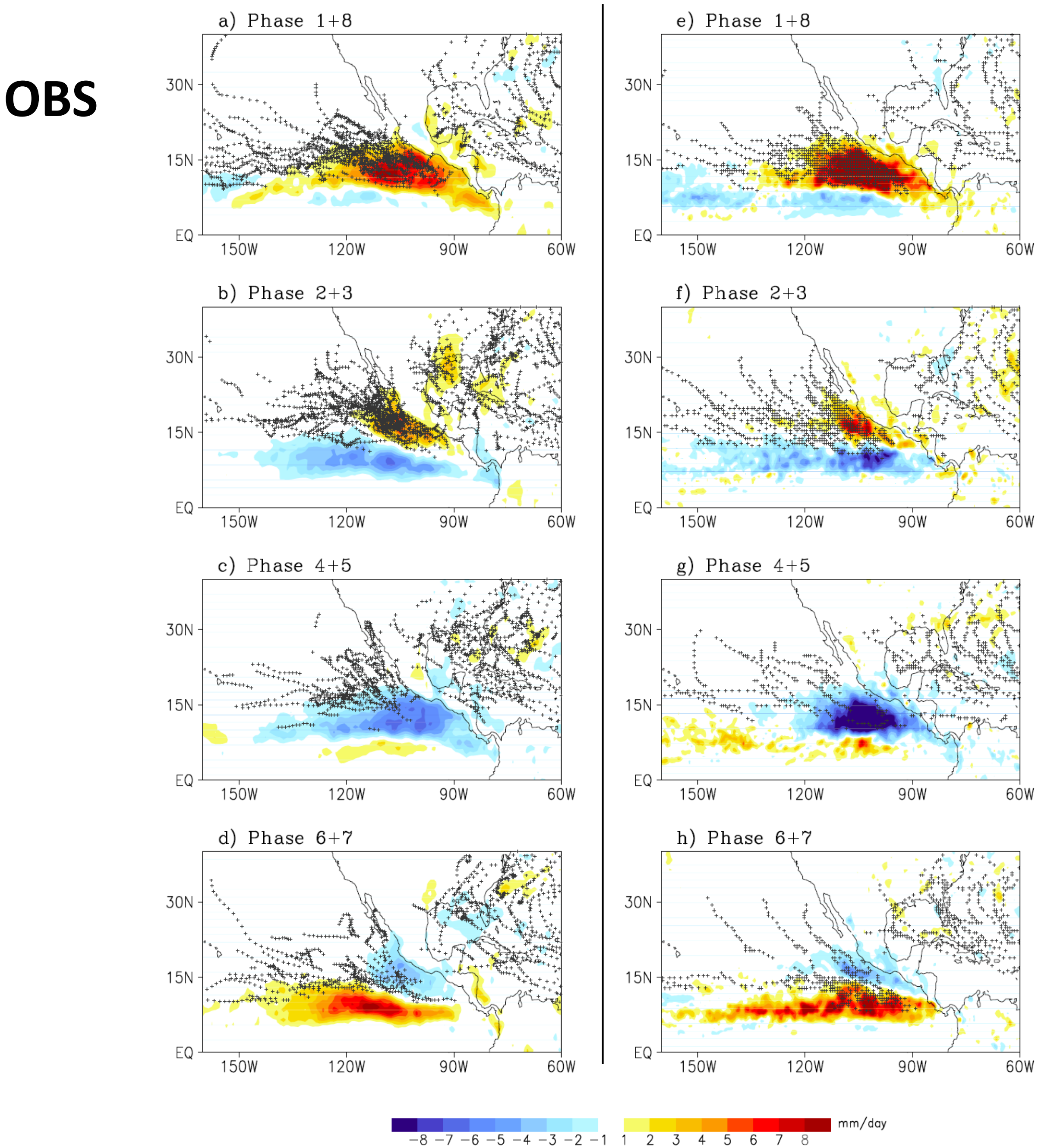


Phase 0 - Weak ISV

HiRAM



Modulation of TC movement by the ISV (1998-2008)



Jiang et al. (2011b)

Genesis Potential Index (GPI)

Emanuel and Nolan (2004); Camargo et al. (2009)

$$GPI = \left|10^5\eta\right|^{3/2}\left(\frac{\gamma}{50}\right)^3\left(\frac{PI}{70}\right)^3\left(1+0.1\cdot V_{shear}\right)^{-2}$$

η 850mb absolute vorticity (s^{-1})

γ 600mb relative humidity (%)

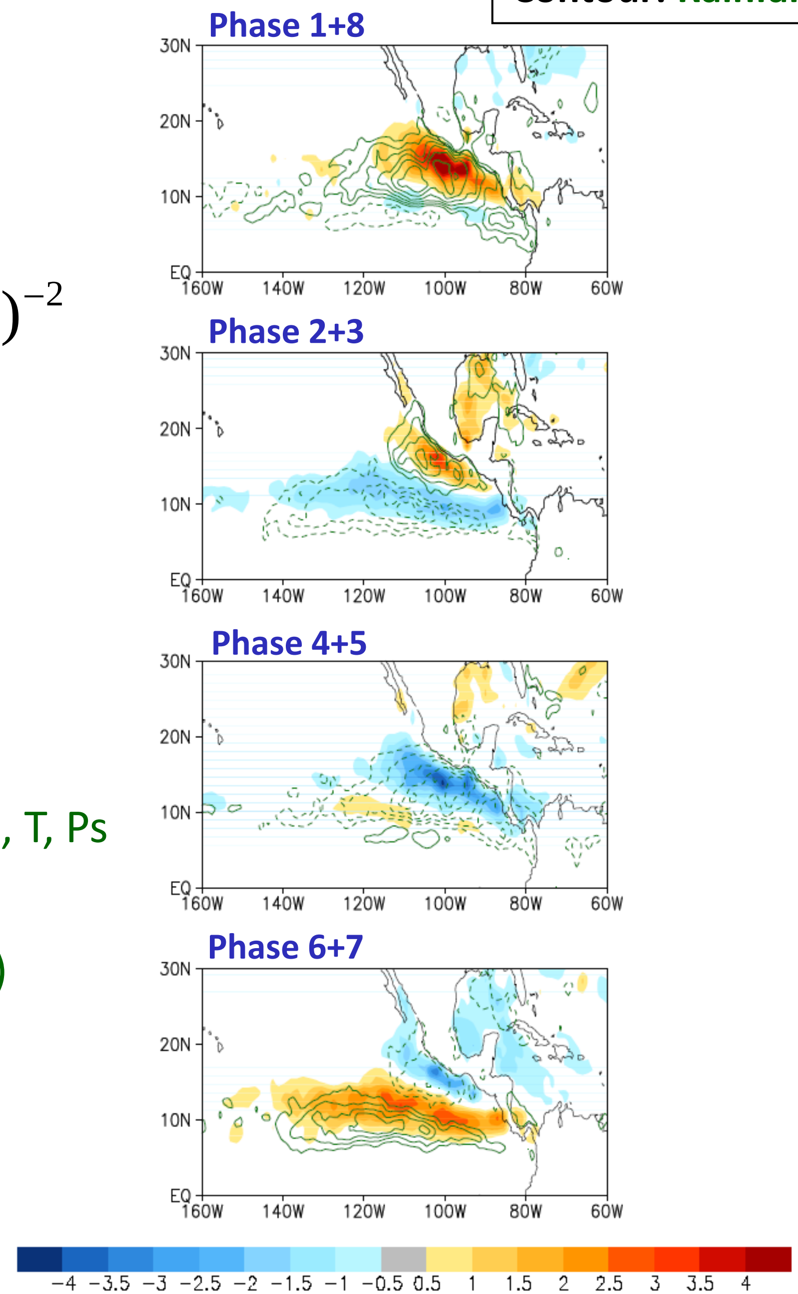
PI Maximum potential intensity (MPI) – SST, q, T, Ps

V_{shear} Vertical wind shear, 200mb-850mb (ms^{-1})

ERA-Interim 1998-2008

Jiang et al. (2011b)

Shading: GPI'
Contour: Rainfall'



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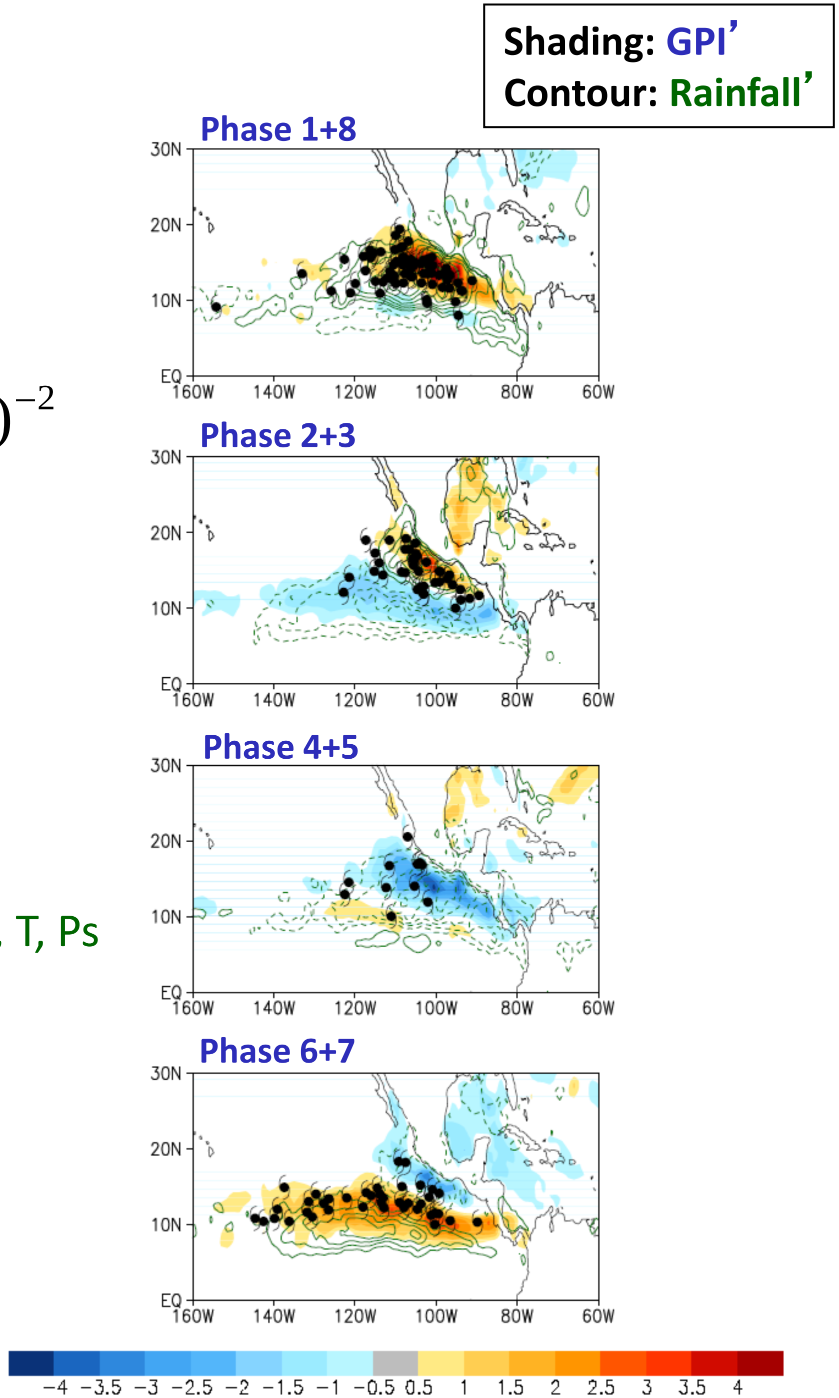
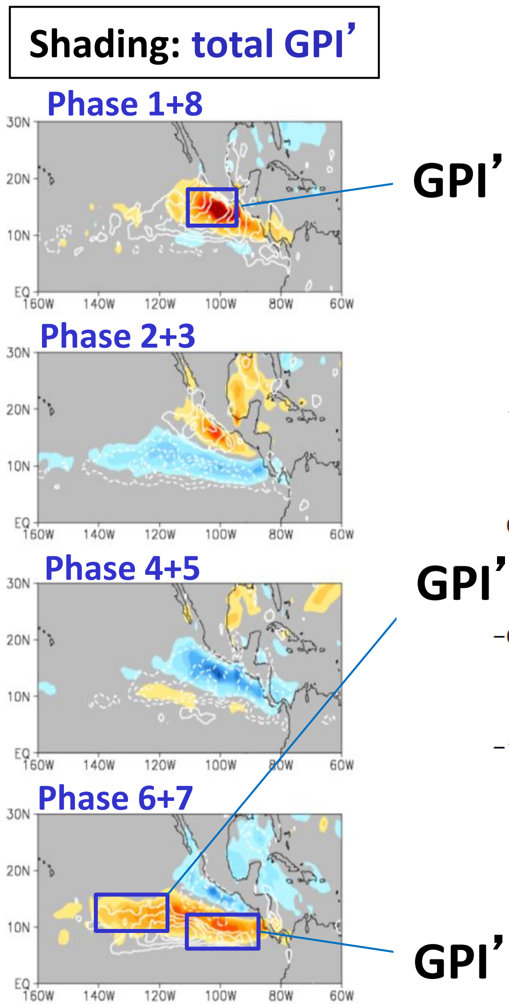
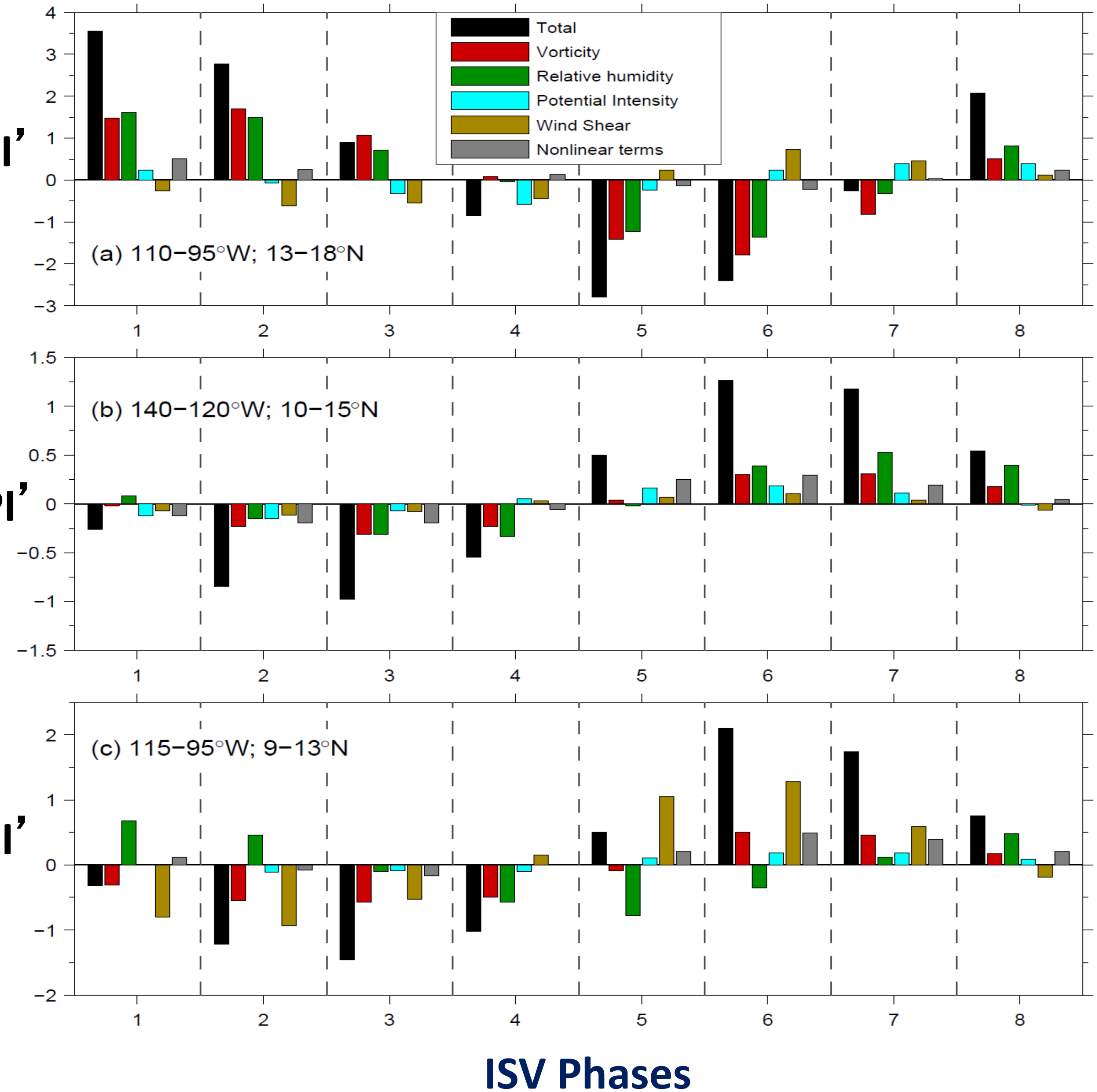


Contributing factors of total GPI'

Jiang et al. (2011b)





Summary

- Two dominant ISV modes over the EPAC, e.g., a 40-day ISV mode and a Quasi-Biweekly Mode (QBM) are identified based on rainfall observations.
- It remains challenging for GCMs in faithfully representing both of these two ISV modes including their amplitude, evolution patterns, and periodicities. In general, SPCAM and GFDL HiRAM exhibit relatively superior skills in representing both of the two ISV modes.
- The newly developed GFDL HiRAM GCM is able to well represent the observed modulations of TC activity over the EPAC by large-scale ISV.
- A budget analysis of the observed GPI anomalies during the ISV life cycle suggests that, relative roles of lower-level cyclonic vorticity, enhanced mid-level relative humidity, and reduced vertical wind shear in modulating TC formation over the EPAC are dependent on ISV phase and location. All of these factors can contribute to active TC genesis over the EPAC during particular ISV phases.
- The results presented in this study suggest great potential of intraseasonal TC forecasts based on high-resolution dynamical models with improved physics.
- Ongoing project / Future Plan
  --- Characterize the role of QBM for regional climate
  --- Explore predictive skill and predictability of the two EPAC ISV modes;
  --- Use HiRAM to explore potential prediction skill and estimate predictability of TC-Activity on IS time scales.

References

- Jiang, X., T. Li and B. Wang, 2004: Structures and mechanisms of the northward propagating boreal summer intraseasonal oscillation. *J. Climate*, **17**, 1022-1039.
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- Jiang, X., M. Zhao, and D. E. Waliser, 2011: Modulation of Tropical Cyclone Activity by the Tropical Intraseasonal Oscillation over the Eastern Pacific in a High Resolution GCM , *Journal of Climate*, accepted with revisions.